Announcements

- Homework for tomorrow…
  - Ch. 33: CQ 1 & 2, Probs. 2 & 3

CQ9: a) arrow @ ~45° b) arrow @ ~-45°
32.26: a) (5.7×10^{-13} N) jhat b) (8.0×10^{-13} N) khat
32.28: a) 1.4401×10^{6} s^{-1} b) 1.6450×10^{6} s^{-1} c) 1.6456×10^{6} s^{-1}
32.34: (2.5×10^{-2} N), to the right

- Office hours…
  - MW 10-11 am
  - TR 9-10 am
  - F 12-1 pm

- Tutorial Learning Center (TLC) hours:
  - MTWR 8-6 pm
  - F 8-11 am, 2-5 pm
  - Su 1-5 pm

Chapter 33

Electromagnetic Induction

(*Induced Currents & Motional emf*)

Last time…

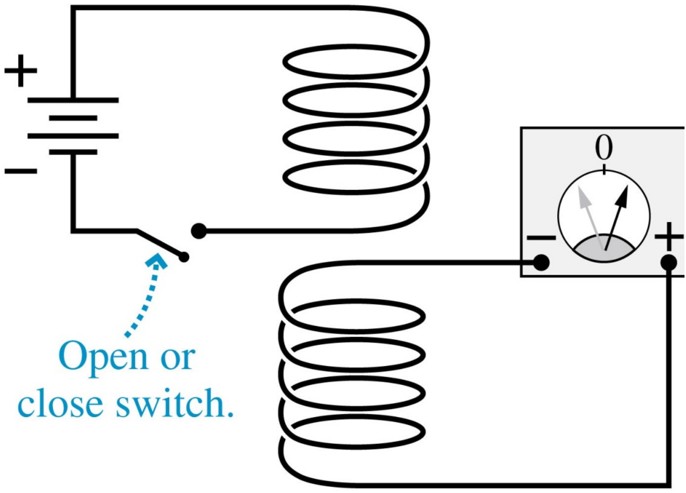
- Torque on a current loop in a *B*-field

$$\boxed{\vec{\tau} = \vec{\mu} \times \vec{B}}$$

33.1
Induced Currents

Michael Faraday's discovery of 1831..

- When one coil is placed directly above another, there is NO current in the lower circuit while the switch is in the closed position.

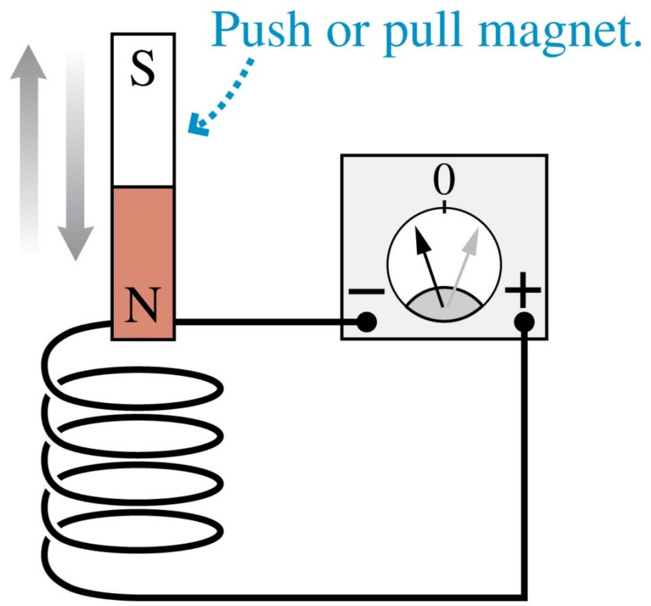


- A *momentary* current appears whenever the switch is *opened* or *closed*.

33.1 Induced Currents

Michael Faraday's discovery of 1831..

- When a bar magnet is *pushed into* a coil of wire, it causes a *momentary deflection* of the current-meter needle.
- Holding the magnet inside the coil has NO effect.
- A quick *withdrawal* of the magnet *deflects* the needle in the other direction.



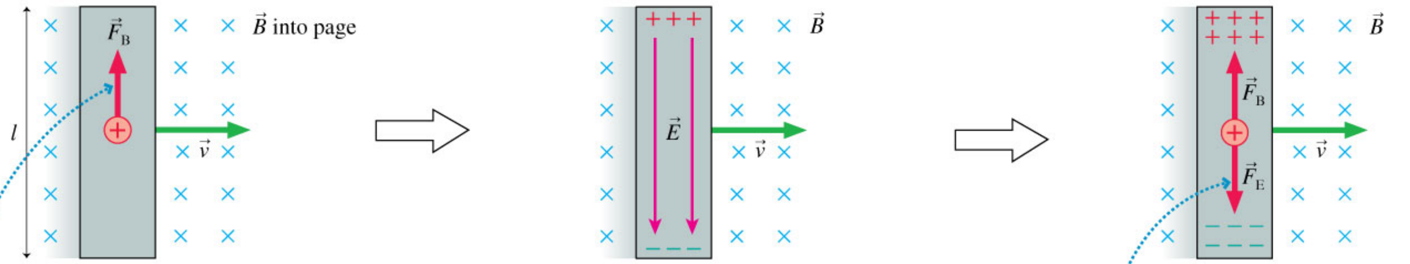
33.1
Induced Currents

Michael Faraday's discovery of 1831..

Faraday found that there IS a current in a coil of wire *if and only if* the *B*-field passing through the coil is *changing*!

33.2
Motional emf

Consider a conductor of length l that moves with velocity v through a *perpendicular uniform B*-field…



Charge carriers in the wire experience an upward force of magnitude $F_B = qvB$. Being free to move, positive charges flow upward (or, if you prefer, negative charges downward).

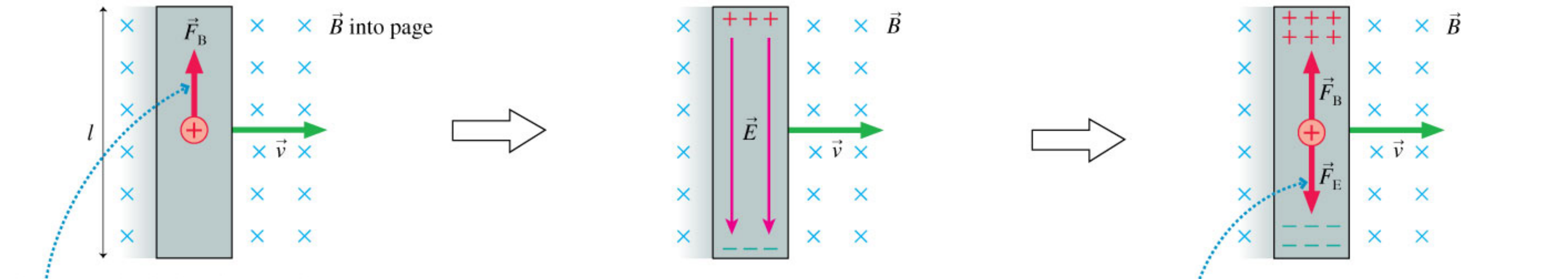
The charge separation creates an electric field in the conductor. $\vec{E}$ increases as more charge flows.

The charge flow continues until the downward electric force $\vec{F}_E$ is large enough to balance the upward magnetic force $\vec{F}_B$. Then the net force on a charge is zero and the current ceases.

What is the *motional emf*?

33.2 Motional emf

Consider a conductor of length l that moves with velocity v through a *perpendicular uniform B*-field...



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What is the *motional emf*?

$$\boxed{\mathcal{E} = vlB}$$

The motion of the conductor through a *B*-field *induces* a *potential difference* between the ends of the conductor!

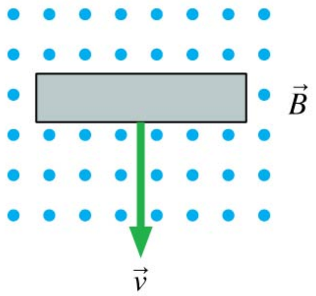
i.e. 33.1
Measuring the earth's *B*-field

It is known that the earth's *B*-field over northern Canada points straight down. The crew of a Boeing 747 aircraft flying at 260 m/s over northern Canada finds a 0.95 V potential difference between the wing tips. The wing span of a Boeing 747 is 65 m.

What is the *B*-field strength there?

Quiz Question 1

A metal bar moves through a *B*-field. The induced charges on the bar are

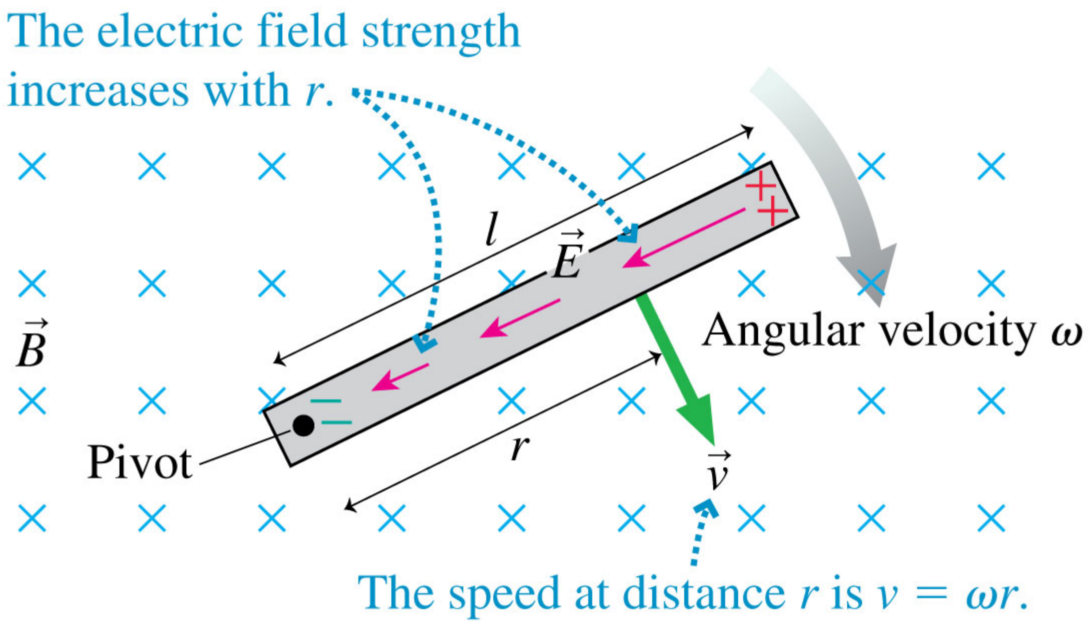


A. B. C. D. E.

i.e. 33.2
Potential difference along a rotating bar

A metal bar of length l rotates with angular velocity ω about a pivot at one end of the bar. A uniform B-field is perpendicular to the plane of rotation.

What is the *potential difference* between the ends of the bar?

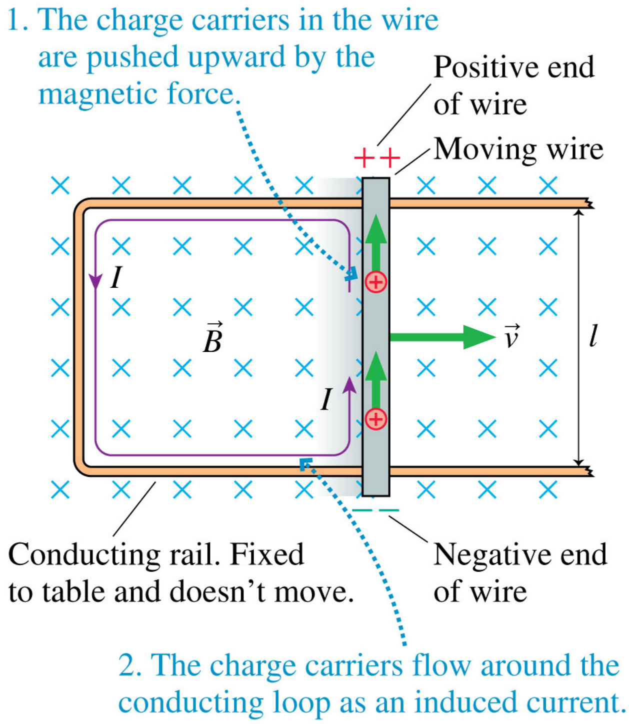


Induced Current in a Circuit…

Consider a wire sliding with speed v along a U-shaped conducting rail..

What is the *induced current* in the circuit?

What is the *force* required to pull the wire with a constant speed v?



Induced Current in a Circuit…

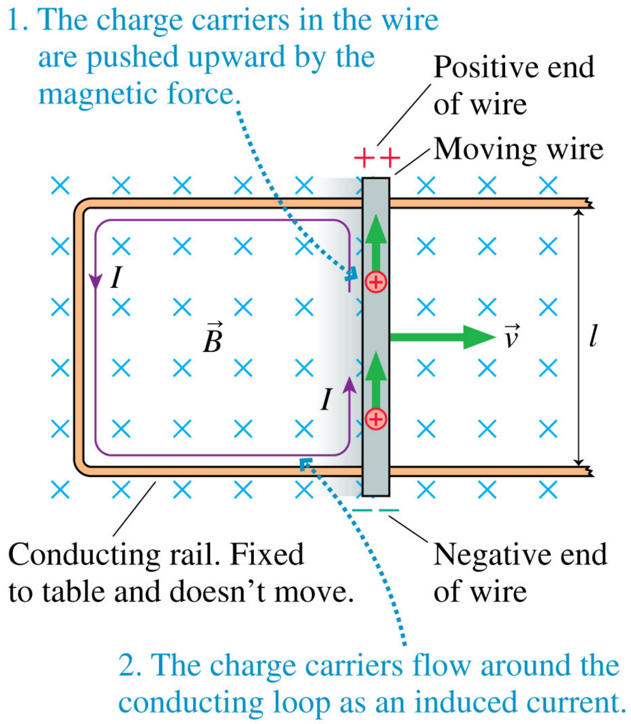
Consider a wire sliding with speed v along a U-shaped conducting rail..

What is the *induced current* in the circuit?

$$\boxed{I = \frac{vlB}{R}}$$

What is the *force* required to pull the wire with a constant speed v?

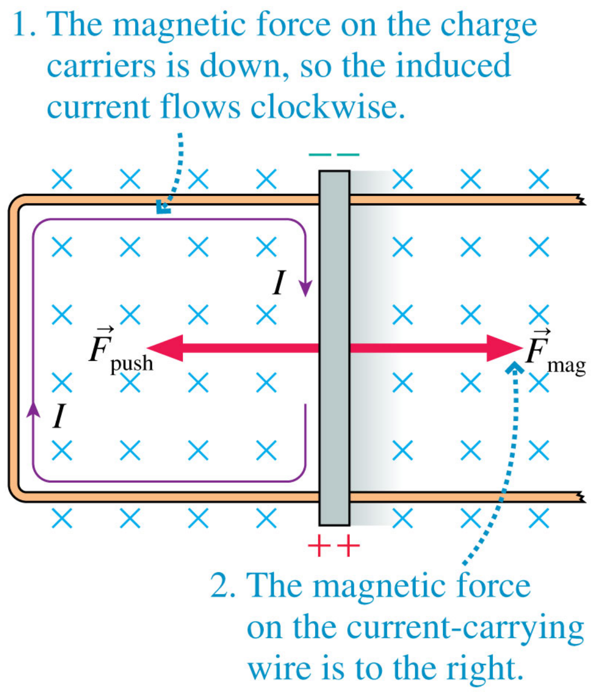
$$\boxed{F_{pull} = F_{mag} = \frac{vl^2B^2}{R}}$$



Energy Considerations…

What happens to the energy transferred to the wire by this work?

Is energy *conserved* as the wire moves along the rail?



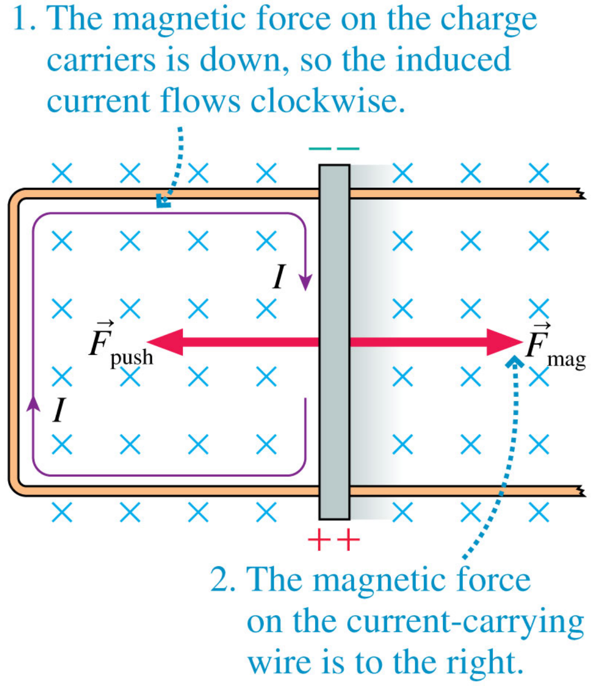
Energy Considerations…

What happens to the energy transferred to the wire by this work?

Is energy *conserved* as the wire moves along the rail?

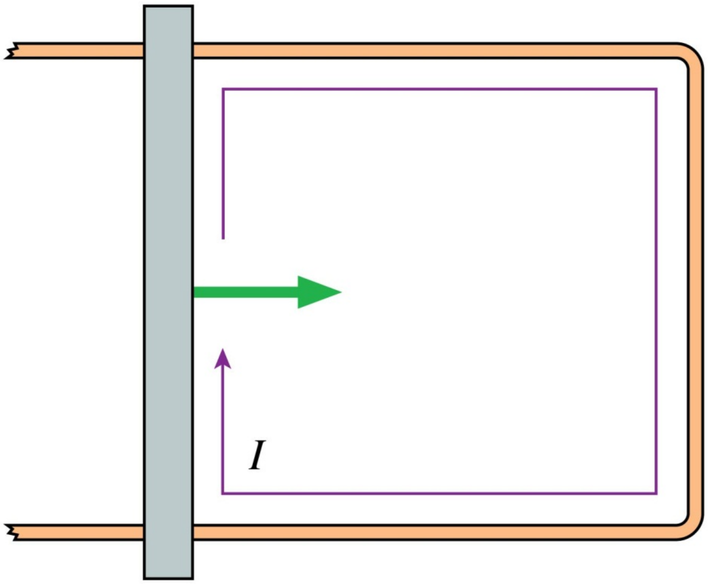
$$P_{input} = P_{dis} = \frac{v^2 l^2 B^2}{R}$$

The *rate* at which *work is done* on the circuit *exactly equals* the *rate* at which *energy is dissipated*.



Quiz Question 2

An induced current flows clockwise as the metal bar is pushed to the right. The *B*-field points



1. up.
2. down.
3. into the screen.
4. out of the screen.
5. to the right.